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ARTICLE

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Pain, hand function, activity performance and apprehensiveness, in patients with surgically treated distal radius fractures

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ABSTRACT

Distal radius fracture (DRF) is a common injury, affecting both function and activity performance. Postoperative rehabilitation is an essential part of the treatment of a surgically treated DRF. The study aims were to assess pain, hand function, activity performance and apprehensiveness and their association, during the first three months after a surgically treated DRF. Eighty-eight patients with a DRF were assessed for pain, hand function, activity performance and apprehensiveness three days and two, six and 12 weeks after surgery. The results indicated that pain, range of motion (ROM), grip strength, apprehensiveness, and activity performance (PRWE) improved significantly between follow-ups ($p < .001$–$.01$). Apprehensiveness correlated moderately with activity performance on all visits (0.40–0.47, $p < .01$), which implies a correlation between the variables, but the regression model showed that the differences in the PRWE at twelve weeks cannot be explained by the differences in apprehensiveness or range of motion at cast removal. At 12 weeks, the study participants had regained almost 70% of their grip strength and 74–96% of the ROM of the uninjured hand.

The study shows that, during the study period, the participants improved in both pain, hand function and activity performance, and indicates that a simple question on apprehensiveness in terms of using the injured hand in daily life could be an important factor in distal radius fracture rehabilitation.

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Distal radius fracture; hand therapy; occupational therapy; rehabilitation; activity performance; apprehensiveness

Introduction

A distal radius fracture (DRF) is one of the most common skeletal injuries. The incidence in Sweden is approximately 22 per 10,000 annually [1]. According to the Swedish Fracture Register, the orthopaedic department in Gothenburg takes care of approximately 1,100 patients with distal radius fractures every year, of which about 35% of the patients undergo surgical treatment [2].

After surgical treatment of a DRF, pain and anxiety can be important factors. The baseline pain intensity following a DRF is described as an independent predictor of chronic pain and can be used to screen for patients at risk of various complications [3]. Anxiety and catastrophic thinking are associated with prolonged recovery after a radius fracture in the form of reduced grip strength, range of motion and activity performance, and complications such as complex regional pain syndrome (CRPS) and finger stiffness [4–6]. Postoperative rehabilitation starting immediately after surgery is therefore an essential part of the management of a surgically treated DRF in order to reduce impairment and shorten recovery time [7]. Early occupational performance intervention, as well as early involvement in a therapy programme, are described as valuable contents of distal radius fracture treatment [7,8].

In order to regain normal hand function after a radius fracture, an early return to daily activities has been emphasized. The main strategy in the postoperative rehabilitation of patients with distal radius fractures is to help the patient reduce the oedema, manage pain, regain range of motion and grip strength [9] and return to everyday life activities. The rehabilitation process includes splinting, mobilisation and strengthening [9], including a return to normal activity through exercises and activities. During the rehabilitation, the occupational therapist (OT) or physiotherapist (PT) both aim to empower the patient to increase his/her activity performance and influence adherence to home exercises, providing motivation, support and encouragement [10].

Rehabilitation is important in order to regain hand function, increase activity levels and reduce the risk of complications [11,12], and home exercises and information has shown to be superior or equal to therapist lead interventions [11,13,14]. Home exercises may be beneficial from the aspect of more active and self-reliant approach to postinjury exercises [13]. An early contact with an occupational therapist, including a dialogue on activity issues, is valuable in the sense that it affects the patients' perceived occupational performance positively [8]. If the patient is

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Table 1. Characteristics of the participants ($n = 88$), mean (±SD) or number of patients (%).

	n
Age, years	Mean 55 (±16)
Gender, female/male	63 (72%)/25 (28%)
Hand dominance	
Right/left	81 (92%)/7 (8%)
Injured hand	
Right/left	37 (42%)/51 (58%)
Injury to dominant hand	
Yes/no	34 (39%)/54 (61%)
Type of injury	
Low-energy*	60 (68%)
Intermediate-energy**	18 (21%)
High-energy***	8 (9%)
Information missing	2 (2%)

*Fall at the same level, such as stumbling on a threshold.
**Fall from <1 metre, such as a fall from a ladder or chair.
***Fall from >1 metre, or traffic accident.

lacking information or knowledge, this can lead to fear of using the hand, which can in turn result in stiffness and pain.

The current study focuses on investigating the outcomes after surgically treated distal radius fractures in the early course after radius fracture, including a structured rehabilitation model starting three days post-surgery. The study aims were to assess pain, hand function, activity performance and apprehensiveness and their association, during the first three months after a surgically treated DRF. The hypothesis was that, during the study period, the patients' hand function and activity performance would improve, that pain would decrease and that apprehensiveness would be correlated to activity performance.

Method

The study was conducted at an orthopaedic hand therapy unit at Sahlgrenska University Hospital (Mölndal) in the south-western part of Sweden. The Medical Ethics Committee in Gothenburg, Sweden, approved the study (ref 891-14) and all the participants gave their written consent to participate in the study.

A total of eighty-eight patients with a surgically treated DRF were included in the study (Table 1). Patients were recruited in consecutive series. Initially, the patients were invited to participate by a research nurse at the operating unit, but, for practical reasons, patients #67 to #88 were asked at their first visit to the hand therapy unit (visit on day three). The inclusion criteria were a distal radius fracture, treated surgically using a volar plate, participation in the visit on day three to an occupational therapist (OT) or physiotherapist (PT) at the hand therapy unit, a minimum age of 18 years and understanding Swedish in speech and writing. The exclusion criteria were other injuries/illnesses to the hand/arm/shoulder, which could affect the possibility of normal activity performance, and cognitive impairment.

The participants were assessed and treated by an OT or PT (who did not participate in the processing or the compilation of the study) at three days and two, six and 12 weeks postoperatively. At three days, 88 participants were evaluated, at two weeks, 85, at six weeks, 82, and, at 12 weeks, 73 were evaluated (Figure 1 – flow chart). The variations at the follow-ups were due to dropouts and to absence for unknown reasons. Two participants dropped out of the study due to personal reasons, one participant due to an EPL rupture and one due to a humeral fracture. Eleven participants were lost to follow ups during the study without reason.

The structured rehabilitation model

The rehabilitation model is the model that is generally used at the orthopaedic hand therapy unit at Sahlgrenska University Hospital (Mölndal). All the patients received rehabilitation according to current clinical practice. The rehabilitation was based on home exercise programme. The rehabilitation included splinting, mobilisation and strengthening [9]. Before the patients left the hospital after the surgery, they received information about the visit to the hand unit on day three. The patients also received written information about the fracture and the treatment ahead, instructions on exercises for reducing and preventing oedema and stiffness, as well as instructions on using the injured hand/arm in daily activities. During the first follow-up information in terms of gender, age, fracture, type of injury and dominant hand was collected. The OT/PT assessed the fitting of the plaster cast, evaluated activity performance, range of motion in non-immobilised joints (thumb, fingers, shoulder, elbow), oedema, sensibility and pain and function in the EPL tendon and carried out relevant interventions depending on the evaluations, such as plaster cast adjustments or extended instructions on oedema treatment. The OT/PT gave instructions on activity/ADL performance, on finger and thumb mobility and oedema prophylaxis, and ergonomic advice was given to minimise the risk of shoulder pain.

The patients routinely wore a cast for two weeks and then a brace for further two weeks, after which the brace was used as deemed necessary. All the patients received a removable wrist brace with volar and dorsal aluminum rails for stable support (Wrist lacer, Camp Scandinavia AB) to use between exercises. At two weeks, exercises for the wrist were introduced, along with continuous efforts to reduce oedema, together with continuous finger- and thumb exercises. The range of motion exercises for the wrist consisted for the most part of volar flexion, dorsal extension, dart throwing motion (DTM), supination and pronation, four times a day, with 10 repetitions. Strengthening exercises and overall hand function activities, with continuous focus on oedema, ROM and pain management, were thereafter the focal points, starting approximately six weeks post-surgery. The strengthening exercises started with manual stabilisation exercises and continued with exercises with silicone dough and elastic exercise bands. The rehabilitation focused on the OT/PT acting to empower and coach the patient to gradually return to normal activities. All rehabilitation was based on home exercise programmes, where the patient is active and self-reliant in the rehabilitation.

Assessment of pain

Pain was measured on a numerical scale (NRS) [15] at the visit on day three, with two questions related to the experience of pain at rest and when making a fist from 0 (no pain) to 10 (worst imaginable pain). The patients estimated their pain numerically. Pain was then assessed at the follow-ups at cast removal, six and 12 weeks, using the pain subscale in the Patient Rated Wrist Evaluation (PRWE) [16]. Since it was not relevant to measure the PRWE three days after surgery, the short rating scale was chosen to indicate and measure pain at that early stage.

Assessment of hand function (oedema, range of motion (ROM) and grip strength)

Oedema (defined here as postoperative swelling) was assessed by measuring the circumference of the wrist, MCP and proximal phalanx of digit III bilaterally, with a tape measure, measured in millimetres [17]. ROM (dorsal extension, volar flexion, supination,

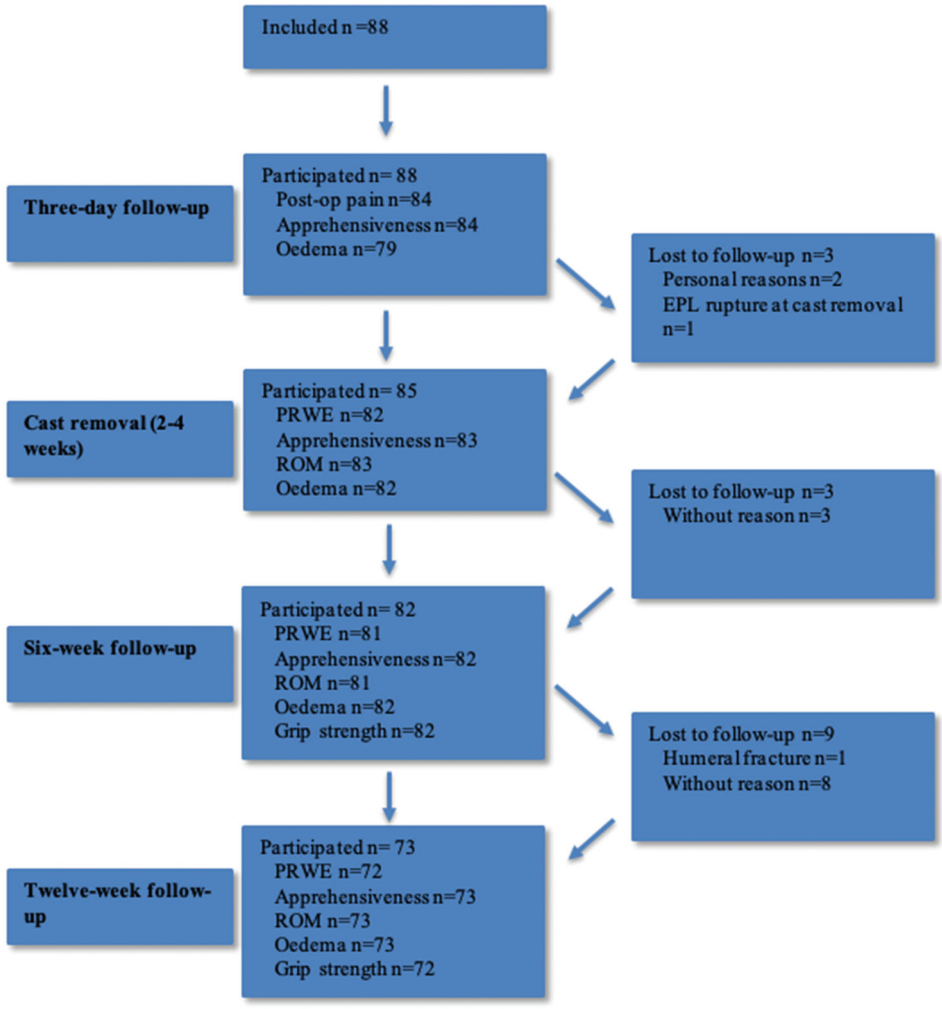

Figure 1. Flow chart.

pronation, radial and ulnar deviation) was measured bilaterally using a goniometer [18] according to HAKIR [19]. Grip strength was measured using a Jamar dynamometer, with the patient sitting, with the elbow flexed at 90° and the forearm and wrist in a neutral position. Both hands were assessed three times each and the mean for each hand was calculated [20].

Assessment of activity performance

Activity performance was measured with the Patient Rated Wrist Evaluation (PRWE) [16]. The PRWE consists of 15 questions, five relating to pain and 10 to function. The score ranges from 0, indicating a well-functioning wrist with no pain, to 100, which indicates functional impairments and severe pain.

Assessment of apprehensiveness

Apprehensiveness was assessed at all the follow-ups with a study-specific, self-constructed question used in clinical practice 'How apprehensive are you about using your injured hand in everyday activities?'. Answers were given on a numerical scale from 0 (no apprehensiveness) to 10 (worst imaginable apprehensiveness).

An overview of assessments is shown in Table 2.

Statistical analysis

The participants' characteristics were presented using descriptive statistics as the mean, standard deviation and percentage.

Changes over time regarding apprehensiveness, the PRWE and ROM were analysed using repeated measures ANOVA. Changes over time regarding grip strength were analysed using Wilcoxon's signed ranked test.

For comparisons between the injured and uninjured hand regarding continuous variables (grip strength, oedema, ROM), the paired t-test was used.

The model of prediction was analysed with linear regression.

Correlation analysis was performed between apprehensiveness and activity performance, using Spearman's rank correlation. When interpreting the strength of the correlation, the thresholds of $r = 0$ for no correlation, $r = 0.1$–0.3 for weak correlation, $r = 0.4$–0.6 for moderate correlation, $r = 0.7$–0.9 for strong correlation and $r = 1$ for perfect correlation were used [21].

A sample size calculation was performed for repeated measures ANOVA evaluating differences in measures at 3 different times. Alpha was set at 0.05 and power 0.90, 1 group, 3 measurements, effect size (partial eta squared) was set to 0.02 indicating a small effect and correlation between times was estimated as 0.4. Using these parameters, a sample size of at least 42 was needed. In order to detect differences in secondary outcomes, be able to perform analyses between groups and compensate for possible dropouts, we aimed to include approximately 90 patients.

Table 2. Overview of assessments.

	Three days	Cast removal (2–4 weeks)	Six weeks	12 weeks
Pain (NRS)	X			
Pain (PRWE)		X	X	X
Apprehensiveness	X	X	X	X
Oedema	X	X	X	X
Range of motion (ROM)		X	X	X
Activity performance (PRWE)		X	X	X
Grip strength			X	X

Results

In general, the cast was removed two weeks after surgery (9–31 days, with a mean of 17.2 ± 5.4 days).

Pain

Three days postoperatively, the patients estimated their pain at rest at a median of 2 (range 0–10) and when making a fist, a median of 3 (range 0–10). Ten participants (12%) rated their pain at rest as a score of 5 or higher, while 21 participants (25%) rated themselves as pain free at rest. There was a significant decrease in pain intensity measured by the PRWE between all three occasions ($p < .001$) (Table 3).

Function *(oedema, ROM and grip strength)*

There was a significant increase in oedema in the injured hand compared with the uninjured hand regarding MCP and the proximal phalanx, dig III, three days after surgery ($p < .001$). The oedema decreased gradually over time, but, at cast removal and at six weeks, there was still a significant difference in terms of the oedema in the proximal phalanx and the wrist ($p < .001$) and the same thing applied at 12 weeks ($p < .001$). However, there were no significant differences between the injured and uninjured hand in the MCP joints, at cast removal and at six or 12 weeks.

Over time, the range of motion in the injured hand gradually increased and the increment was significant for all directions between the different follow-ups (Table 3). There was a significant reduction in the ROM of the injured hand compared with the uninjured hand during the whole study period ($p < .001$) (Table 4). At the 12-week follow-up, there was an improvement in the injured hand, with the greatest improvement in pronation, 77°, compared with 80° in the uninjured hand (96%), and the least in volarflexion, 52° in the injured hand compared with 71° in the uninjured hand (73%) (Table 4).

Grip strength improved significantly over time ($p < .001$) (Table 3), and was also clinically relevant, as the MCID for grip strength is 6.5 kg [22]. At the six- and 12-week follow-ups, grip strength was significantly lower in the injured hand compared with the uninjured hand ($p < .001$) (Table 4). At six weeks, approximately 50% of grip strength had been recovered compared with the uninjured hand, 69% at the 12-week follow-up (Table 4).

At the visit on day three, fifty-nine participants (69%) underwent plaster cast adjustment, re-plastering, or a change/shift from a plaster cast to a removable brace. Between the visit on day three and the time of cast removal, an additional six participants (7%) underwent plaster cast adjustments, re-plastering, or a change/shift from a plaster cast to a removable brace.

Apprehensiveness about using the injured hand

Apprehensiveness about using the injured hand in everyday activities at follow-ups is presented in Table 3. The changes between follow-ups were statistically significant ($p < .001$–$.002$). To summarise, the apprehensiveness increased at cast removal, and then gradually decreased, indicating less apprehensiveness over time.

Twenty-one participants (25%) rated their apprehensiveness as 5 out of 10 or higher at the follow-up on day three. At cast removal, this number increased to 30 participants (36%) and decreased at six and 12 weeks to nine (11%) and two participants (3%) respectively, indicating that a smaller number of patients over time experience apprehensiveness about using the injured hand in everyday activities.

Activity performance

The total score on the PRWE decreased significantly from 52.0 ± 18.4 to 16.6 ± 13.5 between cast removal and 12 weeks ($p < .001$), indicating a higher level of activity at 12 weeks (Table 3). The decrease between each occasion exceeded the MCID of 11.5 points [23], indicating a clinically relevant change. Moreover, the subscores for activity performance decreased significantly during the study period ($p < .001$) (Table 3). The items that caused the most activity restrictions at 12 weeks were carrying a five-kg item with the affected hand, using bathroom tissue and performing leisure activities (table in Appendix).

Correlations and regression models

Correlations are presented in Table 5. Apprehensiveness correlated moderately with activity performance (PRWE) on all visits, which implies a correlation between the variables. However, the regression model showed that the differences in the PRWE at twelve weeks cannot be explained by the differences in apprehensiveness or range of motion in the wrist at cast removal.

Discussion

The study describes a structured rehabilitation model starting three days post-surgery and the relationships between functional measurements and self-assessment outcomes. The study shows that patients increase their function, reduce pain and recover activity performance over time. At cast removal, all the patients were reported to have pain, oedema, reduced ROM and activity limitations, which decreased significantly during the following three months. At three months, 46 of 72 participants (64%) stated that they had no pain at rest, while 38 of 73 participants (52%) stated that they had no apprehensiveness whatsoever when using their injured hand in everyday activities. At 12 weeks, the study participants had recovered almost 70% of their grip strength and between 74% and 96% of the ROM in the uninjured hand, on average. This is consistent with previous findings by Ydreborg et al. [24].

The study implies that self-perceived apprehensiveness about using the injured hand was correlated with activity performance during the entire follow-up period, but is in terms of the regression analyses not an explanatory factor. This is probably due to

Table 3. Range of motion (degrees), grip strength (kg), apprehensiveness and PRWE in the injured hand during the first 12 weeks after the fracture, mean ± SD (range).

	Three days	Cast removal (2–4 weeks)	Six weeks	12 weeks
Range of motion $n = 71$				
Supination°	–	39 ± 26	60 ± 21*	74 ± 15*
Pronation°	–	60 ± 15	72 ± 11*	77 ± 10*
Dorsal extension°	–	33 ± 12	49 ± 11*	60 ± 11*
Volar flexion°	–	22 ± 12	40 ± 14*	52 ± 14*
Radial deviation°	–	10 ± 5	15 ± 6*	18 ± 5*
Ulnar deviation°	–	16 ± 7	22 ± 8*	26 ± 7*
Grip strength, kg $n = 73$	–	–	15.0 ± 9.0	21.8 ± 10.0*
Apprehensiveness (0–10) $n = 69$	2.5 ± 2.7 (0–10)	3.6 ± 2.7 (0–10)§	2.2 ± 2.0 (0–8)*	1.0 ± 1.2 (0–6)*
PRWE $n = 71$				
Pain (0–50)	–	20.8 ± 9.9 (0–46)	15.0 ± 8.8 (0–36)*	9.6 ± 7.5 (0–37)*
Function (0–50)	–	31.0 ± 10.5 (4–50)	16.7 ± 10.0 (0–46)*	7.1 ± 7.0 (0–32)*
Total score (0–100)	–	52.0 ± 18.4 (8–92)	31.8 ± 17.7 (2–72)*	16.6 ± 13.5 (0–66)*

*$p < 0.001$, §$p < 0.01$.

Table 4. Difference in range of motion (degrees) and grip strength (kg) between injured/non-injured hand.

	Cast removal (2–4 weeks) Injured hand/non-injured hand ± SD	Mean difference ± SD	Six weeks Injured hand/non-injured hand ± SD	Mean difference ± SD	Twelve weeks Injured hand/non-injured hand ± SD	Mean difference ± SD
Range of motion $n = 71$						
Supination°	39 ± 26/83 ± 9	−44 ± 26	60 ± 21/83 ± 8	−23 ± 20	74 ± 15/83 ± 9	−9 ± 13
Pronation°	60 ± 15/79 ± 8	−19 ± 15	72 ± 11/79 ± 8	−7 ± 10	77 ± 10/80 ± 8	−3 ± 7
Dorsal extension°	33 ± 12/67 ± 10	−34 ± 13	49 ± 11/67 ± 9	−18 ± 16	60 ± 11/68 ± 9	−8 ± 9
Volar flexion°	22 ± 12/70 ± 11	−48 ± 15	40 ± 14/70 ± 11	−30 ± 15	52 ± 14/71 ± 11	−19 ± 12
Radial deviation°	10 ± 5/20 ± 7	−10 ± 7	15 ± 6/21 ± 7	−6 ± 7	18 ± 5/21 ± 7	−3 ± 6
Ulnar deviation°	16 ± 7/32 ± 8	−16 ± 9	22 ± 8/31 ± 7	−9 ± 8	26 ± 7/32 ± 7	−6 ± 7
Grip strength, kg $n = 72$	–	–	15.1 ± 9.0/29.8 ± 11.1	−14.7 ± 9.2	22.0 ± 10.0/31.5 ± 12.3	−9.5 ± 7.6

$p < 0.001$.

Table 5. Correlations between apprehensiveness and PRWE total score and subscores (pain and function) (correlations >0.4 in bold text).

	PRWE at cast removal (2–4 weeks)			PRWE at six weeks			PRWE at twelve weeks		
	Pain	Function	Total	Pain	Function	Total	Pain	Function	Total
Apprehensiveness at 2/6/12 weeks	**0.43****	**0.42****	**0.47****	**0.43****	**0.46****	**0.46****	**0.40****	**0.46****	**0.46****

**Correlation significant at the 0.01 level (2-tailed).

that the correlation analyses were made on raw data at each study point and the regression model on differences between the time points. Although it was not an explanatory factor, the results indicate that the fast, easily performed evaluation of apprehensiveness is an important factor to consider for patients during distal radius fracture rehabilitation but that the variations in the PRWE are multifaceted.

The hand oedema decreased gradually during the study period. There were significant differences compared with the uninjured hand in the proximal phalanges and the wrist but not in the MCP joints. It is possible that minor oedema might not have the same impact on activity performance as range of motion and grip strength, for example, which indicated larger differences between the injured and uninjured hand in the study. The reliability of measurements in the MCP joints may, however, be lower, as they are difficult to measure.

One advantage of an early intervention like the one described in the present study is the opportunity to detect the need for cast adjustment and identify patients who do not understand the oedema prophylaxis instructions, are in need of more intense rehabilitation or advice in performing daily activities. In addition to the above, Grönlund et al. [25] concluded that occupational therapy initiated at an early stage resulted in improved hand function at cast removal [25]. This is also in harmony with other previous studies; Dahlqvist and Rosén [8], for example, reported the importance of early occupational performance intervention as a valuable contribution to distal radius fracture treatment, affecting the patients' occupational performance, including a significant improvement in their ability and independence [8].

The design of this study with a consecutive series of patients, but lacking a control group, is a limitation when interpreting the results. Another limitation is that we have no data related to patients who declined to participate in the study, but the patient sample nonetheless appears to be representative of the patient group. One limitation of this study is that we did not include any kind of personality factors and we did not include aspects relating to adherence to recommended training, which makes it difficult to conclude what affected the outcomes. Moreover, we did not adjust for the dominant hand when measuring grip strength, which could have affected the results. Another limitation is the non-validated single question about apprehensiveness, which has not been tested or evaluated before. The question was formulated to test whether this single and simple question could be used to predict outcome.

Conclusion

The study shows that the patients improve in both pain, hand function and activity performance, during the first three months after a DRF. Although apprehensiveness was present during the rehabilitation process, the patients still improved at both functional and activity levels. The study indicates that a simple

question on apprehensiveness in terms of using the injured hand in daily life is correlated to the self-perceived activity performance measured with the PRWE and could therefore be an important question in distal radius fracture rehabilitation.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix

Information on PRWE item response at follow-ups

Question	Cast removal (2–4 weeks) Mean ± SD	Six weeks Mean ± SD	12 weeks Mean ± SD
Pain scale			
At rest	1.7 ± 2.0	1.0 ± 1.2	0.6 ± 1.2
Repeated movement	4.2 ± 2.7	2.5 ± 1.8	1.9 ± 1.6
When lifting	6.6 ± 3.4	4.7 ± 3.2	2.4 ± 2.1
At worst	5.1 ± 2.6	4.1 ± 2.6	2.8 ± 2.1
Frequency	3.1 ± 2.1	2.4 ± 2.1	1.9 ± 1.8
Specific activity			
Turning a tap on/off	6.7 ± 3.2	3.2 ± 2.8	1.6 ± 1.9
Cutting meat	6.5 ± 3.2	3.4 ± 3.0	1.4 ± 1.8
Fastening buttons	4.6 ± 3.3	1.9 ± 2.2	0.7 ± 1.3
Pushing up from chair	6.7 ± 3.7	3.6 ± 3.4	1.7 ± 2.2
Carrying 5 kg	8.7 ± 2.8	6.2 ± 4.0	2.2 ± 2.8
Using bathroom tissue	7.3 ± 3.6	4.2 ± 3.7	1.8 ± 2.7
Usual activity			
Personal care	4.0 ± 2.8	1.7 ± 2.0	0.7 ± 1.2
Household work	5.5 ± 3.1	2.6 ± 2.5	1.1 ± 1.3
Work	6.0 ± 3.4	3.1 ± 3.0	1.3 ± 1.6
Recreation	6.6 ± 3.4	3.7 ± 3.3	1.8 ± 2.3
Pain score (50)	20.8 ± 10.3	14.7 ± 8.6	9.6 ± 7.4
Function score (50)	31.2 ± 11.3	16.8 ± 10.1	7.1 ± 7.0
Total score (100)	52.3 ± 19.2	31.7 ± 17.5	16.8 ± 13.5